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The Classroom Communicator, an experimental machine built at Pennsylvania State College, is both a research and a mass teaching aid device. It will record and measure reactions of individuals in an audience, almost instantaneously, and will help improve the rate and effectiveness of learning. This report shows in detail that, to a large extent, the experimental model meets its pre-design functional requirements. The Communicator will handle multiple-choice objective tests, or attitude scales, in such a way that the results are available directly after the conclusion of the test. Furthermore, the instructor or experimenter can see immediately how each individual responds to each item in the test. After its experimental stage, the machine may serve as a starting point for other models designed for other specific functions, and its design suggests future adaptations for use in mammoth organizations, such as the U. S. Congress and the United Nations, where results of votes, for example, need to be analyzed, summarized and made known immediately, and where complete records of the responses of individuals participating in policy making or decision groups may be needed. (GO)

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TECHNICAL REPORT - SDC 269-7-14

THE CLASSROOM COMMUNICATOR

SPECIAL DEVICES CENTER

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THE CLASSROOM COMMUNICATOR

(Rapid Mass Learning)

The Pennsylvania State College
Instructional Film Research Program
October 1950

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SUMMARY

This is a report of the planning, design and construction of experimental equipment appropriate for research on the learning process and the evaluation of complex instructional and informational programs.

The Classroom Communicator makes possible, among other things, the administration of multiple-choice objective tests, or attitude scales, in such a way that the results are available directly after the conclusion of the test. In addition, the instructor or experimenter can see immediately how each individual responds to each item in the test. Other features of the system will make possible new kinds of experimentation in the learning process.

The pre-design functional requirements for the equipment are given in detail. The equipment which has been designed and constructed to meet these requirements is described and illustrated. An explanation is given of how the components of the Classroom Communicator operate. This section of the report also describes the various controls and the functions they perform. The operational characteristics of the system as it now exists are outlined along with plans for using the equipment in research.

Finally, a number of other possible practical uses for a system like the Classroom Communicator are suggested.

THE CLASSROOM COMMUNICATOR

INTRODUCTION

Research on the complex problems of communication processes requires instrumentation which is appropriate to the problems being investigated. This is particularly true of the aspect of communications research which deals with the instructional sound motion picture.

During the planning stages of the Instructional Film Research Program in 1947 it became clear that available equipment and instruments were not adequate for investigating the problems which would be formulated. There are many limitations to the collection of data through the use of written tests, even when supplemented by test-scoring machines or punched-card systems.

Several kinds of "audience analyzer systems" had been developed and used. Equipment for measuring individual responses and learning required characteristics different from those systems which record combined or summated curves for the like-neutral-dislike responses of all members of an audience.

Late in 1947, the Special Devices Center requested the Instructional Film Research Program to develop an enlarged and improved version of its first experimental Classroom Communicator. The specifications furnished by the Center were in the form of general functional requirements. It seemed probable that this device could be modified and developed to meet the requirements for research in instructional films.

It was believed that the equipment could be planned and constructed to do two things: 1. Provide a means for recording and measuring the reactions of individuals in audiences. 2. Provide a means for improving, facilitating, or increasing the rate and effectiveness of learning. These functions were to be performed by the equipment, under conditions of group instruction principally by means of sound motion pictures.

A Committee* was formed of psychologists, educators, engineers, and physicists for planning the equipment which was needed. In the beginning the lead was taken by the investigators who would eventually use the equipment. The specific task was that of modifying and enlarging the list of original functional requirements.

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* C. R. Carpenter, J. Gaberman, G.L.Haller, N. Jaspen, F. T. John, A. K. Kurtz, A. A. Lumsdaine, S. Roshal, and M. Scott.

The formulation of the functional requirements was a task which extended over many months. The central and most difficult problems was that of imagining what would be required of an ideal system for recording a wide range of reactions of individuals in groups as they responded to instructional programs. It was decided that the principal method of testing would be the administration of objective-type questions either during or immediately following the presentation of an instructional film or other kind of program. The Committee was especially alert to the measuring and recording requirements, but in addition the Committee decided to provide for the possibility of building into the system the means for improving the effectiveness of instructional programs. This was to be done by involving the audience in the program by requiring individuals to respond actively (participation), by informing individuals immediately of the results (correctness or incorrectness) of their responses, and by making it possible to arrange for group competition and cooperation during learning.

Furthermore, it was decided that the system should be a discrete-number system rather than a continuous-scale system. In other words, the results should be available in the form of discrete whole numbers rather than in the form of a continuous scale on which numerical values have to be read by interpolation.

Eventually the modified list of functional requirements was completed and used as a guide for designing and constructing the Classroom Communicator. These ideal functional requirements were stated without regard to the engineering problems which might be met during the design and construction phases of developing the equipment.

The list of functional requirements drawn up by the Committee in October 1947, is presented in the next section. The list given here as part of this report is essentially the same as that of the Committee except for some changes in the order in which the items are presented, and some changes in technical nomenclature to make the list conform to current usage.

The functional requirements were specified under four headings: (1) general requirements, (2) essential characteristic, (3) desirable characteristics, if not too expensive, (4) mildly desirable characteristics.

FUNCTIONAL REQUIREMENTS

General Requirements

The proposed Classroom Communicator, should be a system which will be useful both for research and instruction. It shall be designed and constructed especially for the rapid and accurate testing, and recording of responses, of individuals in groups. In addition, the system shall make it possible to reinforce instruction and facilitate learning.

Essential Characteristics

1. The device shall be built to provide for 40 response stations.

2. The device shall provide for using any number of the response stations, i.e., although it is built for a total of 40 stations, the machine must be easily and quickly adjustable to provide for any smaller number.

3. The equipment shall be designed and constructed so as to provide for plugging in additional units of 20 stations each, so as to produce larger and more flexible systems. When two additional units are combined with the original system, it should be possible to get percentage of correct and incorrect responses, etc., for classes of all possible sizes from ten to one hundred and twenty individuals.

4. The response station for each individual shall be equipped with keys to provide for five alternative responses.

5. The response stations should be constructed so as to insure privacy of responses, in order that individuals shall not influence one another.

6. The device must eliminate possibilites of double or multiple answers to any one item. However, it is necessary to provide means for an individual to change his response within a time limit determinable by the observer or instructor.

7. The device must allow for the possibility of omissions by any student of any questions, treating omissions as wrong answers (except as otherwise indicated in Items 24 and 26).

8. There should be an immediate indication to the instructor of the failure of any response station.

9. The system shall give immediate indication to the observer or instructor of the percentage of correct answers made by the group being tested (not the number responding) for each test item, as soon as the students or trainees have made their responses to it. This is an indication of the difficulty of the item for the group.

10. Multiple dials or indicators shall show the instructor or observer the percentage of individuals choosing each alternative. Indications on all dials must be given simultaneously.

11. Dials and indicators relating to responses to each question must be accurately and easily readable under degrees of illumination down to complete darkness without affecting visability of motion pictures projected on screens. However, the total score indicators (Item 13) need not be designed to be read in the dark.

12. The machine should have a grid or other device to show the instructor the rightness or wrongness of the response of each student on the current item. This might take the form of an 8 x 5 set of squares covered with ground glass with a light in each cell, so that if students 9 and 17 missed or omitted an item, positions 9 and 17 would be dark, while all other cells would be lighted. A permanent record of this, perhaps in some other form, would be to some extent desirable.

13. The device shall record and present a total test score for each student at the end of a test period.

14. The device shall make it possible for the observer, or instructor, to press a button, or otherwise indicate to the machine the correct answer. A permanent record of this indication is desirable.

15. The device shall make it possible to inform simultaneously and immediately each individual in the group of the correctness, or incorrectness, of his response to the item just answered. Whether or not this is to be done should be at the discretion of the instructor.

16. Under ordinary operating conditions, the indicator dials should give accurate results. Only rarely (say 1% of the time or less) should the "percentage difficulty" of items as read in the usual manner by the instructor be as much as 2% away from the true value. Further, the total score for each student must not differ by as much as one item except in extremely rare instances (say 1/2 of one per cent of the time or less). Errors in reading dials, or other indicators or graduations, are just as real and important as mechanical or electrical errors which cause the machine to make errors. Therefore, the dials should be so constructed as to make it possible for the operator to read them accurately.

17. The machine must give accurate results regardless of variations in humidity, temperature, electro-static fields, fluctuations in local line voltage, atmospheric pressure, amount of pressure on keys, etc., within reasonable limits. In no case shall the maximum error due to an adverse combination of such factors be over 2% in addition to the errors referred to in Item 16, and the error shall be ordinarily less than 1%.

18. The machine must be transportable from one location to another.

Desirable Characteristics if not too Expensive

19. The equipment should indicate the number of right answers in addition to indicating the percentage of right answers. (See Item 9). It should be possible for the instructor to read, or easily adjust the equipment for reading, either percentages of right answers or number of right answers as well as the percentages of the other possible responses.

20. The instructor should have a cumulative score which finally yields a total score for each individual.

21. The machine should provide for the use of a key-card (prepared in advance) for keying the correct answers. This is in addition to (not instead of) the usual method described in Item 14. This is particularly important with respect to attitude scales. (See Item 24).

22. A complete record should be available of the responses of each individual to each item for the purposes of item analyses.

23. There should be provision for dividing the class into two sub-groups (in any way the instructor wishes), and securing separate "item difficulty figures" for each sub-group. This may be done by additional indicators, by flicking switches, or by other means. It is not necessary to secure total scores for the sub-groups, since the total scores of the individual students can be added when necessary.

24. The equipment should sum scores on multiple choice items of attitude scales in which each of as many as five responses would have different numerical weights either of the type 0, 1, 2, 3, 4, or of the type 4, 3, 2, 1, 0. There must also be a provision for automatically adding 2 for each item omitted by a student.

Mildly Desirable Characteristics

25. The machine should have a grid or other device ot show the instructor the answer that each student gives to the current item. This might take the form of an 8 x 5 set of squares covered with ground glass with 5 lights in each cell, each with a different colored lettered light corresponding to one of the 5 responses. A permanent record would be desirable.

26. The machine should be adjustable to give total scores for each student of the type $R - \frac{1}{n-1} W$ rather than merely the number of right answers. E.g., for five-choice items, the instructor should be able to set the machine to total the number of right responses minus one-fourth the number wrong.

27. There should be a permanent record of the "difficulty" of each item.

28. There should be a permanent record of the percentage of students giving each of the five (or less) possible responses to each item.

29. There should be a permanent record of the total score of each student.

30. The machine should be built, insofar as practical, of standard rather than specially constructed parts.

31. The machine should be so designed as to facilitate servicing and repairing.

It should be understood that these functional requirements were stated as a guide for the designers and engineers. It was scarcely to be hoped that equipment could be built which would have all of the specified characteristics. In actual fact the functional requirements were all met with the exception of the following: the percentage interpolator (9, 10), provision for additional groups of response stations (3), automatic error indicator (8), discontinuous printer (27, 28, 29), scoring responses $R - \frac{1}{n-1} W$ (26).

The task of constructing equipment of the kind under consideration is difficult and challenging. The question was raised as to whether or not a College should undertake such research and development work. Although there was much to be said for sub-contracting with a specialized industrial shop, the following reasons seemed to weigh heavily in favor of the work being done here in the College: 1. The total cost was estimated to be lower. 2. There were greater possibilities for modifying designs or actual construction while the work was in progress thus insuring that the final equipment would more nearly meet the functional specifications. 3. The psychologists and educators, as well as other research people and consultants, could work more closely with the designers and engineers than if the work were done by a remote industrial concern.

A determining factor in deciding to attempt the construction of the equipment at The Pennsylvania State College was the agreement which made available the facilities and skilled craftsmen of the Physics Shop for this work.

THE EQUIPMENT

The five major components of the equipment are illustrated in Fig. 1. They are:

1. The Response Stations. Forty individual response stations are located on the arm rests of the seats. These are semi-private and contain five piano-like keys. By means of these stations, subjects may register their responses to a multiple choice or true-false question and to attitude scales by pressing a selected key. The keys make it possible to select and register one answer or response among five alternatives.

2. The Console. The console houses most of the functional mechanisms of the system. These include the relay panels, the power supplies, and commutators. The Console has a large panel on which are mounted most of the controlling and indicating devices.

3. Classroom Correct Answer Lights. The correct answer lights are in the front of the room in clear view of the class, and are used to signal the correct answer to the group immediately after the end of the response period.

4. Total Score Indicators. The bank of 40 electromagnetically operated counters is arranged in a pattern which corresponds to the pattern of seats in the room. These counters accumulate and indicate total scores for each individual in the group.

5. Film Analyzer.* The Film Analyzer, a device used in evaluating programs such as films, may also be used with the Classroom Communicator as a recorder. It is a continuous recording polygraph which prints a code indicating which key was selected at each response station, along with time marks and film footage marks for use in analyzing a motion picture. The record produced by this device shows the answer or alternative selected, time required by each individual in a test situation to make a selection or decision, and the number of times the choice was changed before a final decision was made. In short, the Analyzer records the selection and timing of all responses made through the response stations.

Theory of Operation

The Classroom Communicator is a complex system of relay operated devices. The inter-relationships are shown in Fig. 2. In general, these devices may be placed in the following categories: (a) information input devices, (b) control devices, (c) intermediate functional mechanisms, and (d) indicating, tabulating, and recording devices.

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* The Film Analyzer is described in detail in a separate report, SDC-269-7-15.

Fig. 1 Classroom Communicator system showing: Response Stations (bottom), Console (left), Film Analyzer printer (center), Total Score Indicator (right), and Classroom Correct Answer Lights (top center).

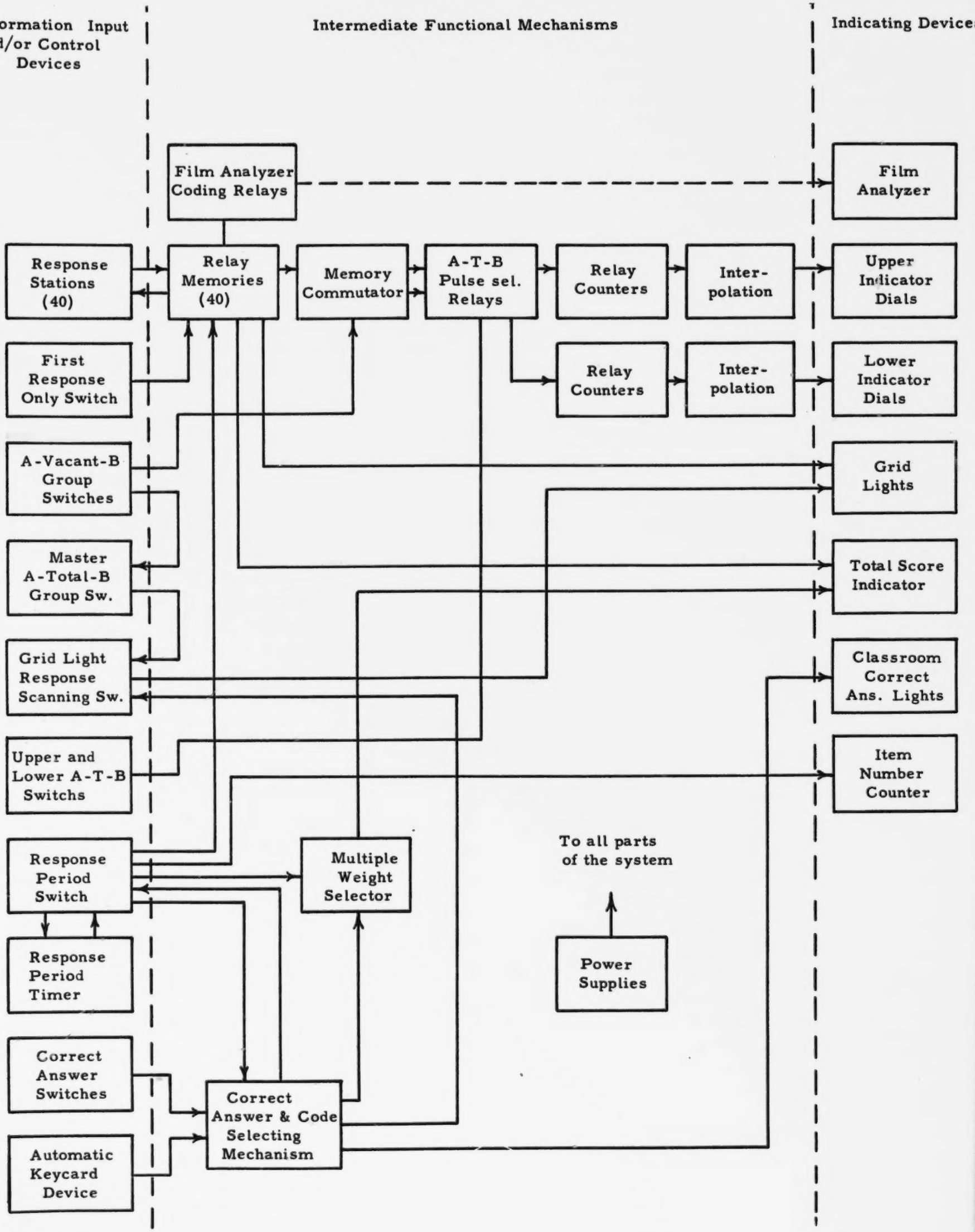

Fig. 2 Block diagram of overall system arranged to show relation of the input, intermediate, and output devices.

Response Stations. The first category, information input devices, consists of the 40 response stations, Fig. 3a shows one of these stations. The number on the top indicates the seat or station number. Fig. 3b shows a response station with the cover removed. The five keys are numbered from left to right, 1 through 5. They are mounted on lever arms which are mechanically linked to the armatures of the relays at the left. When any key is depressed, it closes the corresponding relay, which is electrically connected so as to lock down. Thus, the key is held down and the other keys cannot be depressed without releasing the previously selected key. The electrical connections which accomplish this are illustrated in Fig. 4a, which is a partial circuit of a response station. It can be seen that for any relay to lock down, the other four relays must be open. If any other relay is operated, it will interrupt the current supply to the locked one, causing it to release. After this relay releases, the one being depressed will lock down. Fig. 4b shows the number three key down and the conducting path drawn in with heavy lines. This arrangement enables the subject to select only one key at a time, to change his response at will, and to have at all times a tactual and kinesthetic reminder of which key he has selected.

The response period may be terminated by switching the source of power from that shown in Fig. 4 to an arrangement which supplies power directly to the coil of the locked-down relay. This is accomplished through a set of five "memory" relays for each response station, located in the Console. These relays have their coils connected to those of the response station so that they duplicate the action of the response station relays. Throwing the response period switch into "lock stations" position causes power to be supplied through the contacts of whichever memory relay is closed, to the corresponding response station relay. Thus, the last key selected at each response station will remain locked down. It is now impossible for the subject to change his response, and he can be told the correct answer which he can compare with his response.

Response Period Switch (Fig. 5. control 3a).

As described above, the primary function of the response period switch is to control the duration of the response period by locking the depressed key (if any) of each response station. This switch has many circuits which interlock with other parts of the system, thus giving it a number of secondary functions. These are listed below:

A. When stations are locked:

1. Subjects cannot change their responses.
2. Correct answers are presented to the group.
3. Individual total score indicators operate.
4. Response period timer stops when used manually.
5. Memory commutators start, causing relay counters and indicators dials to operate.
6. Warning signal lights up if no correct answer has been inserted in the machine.

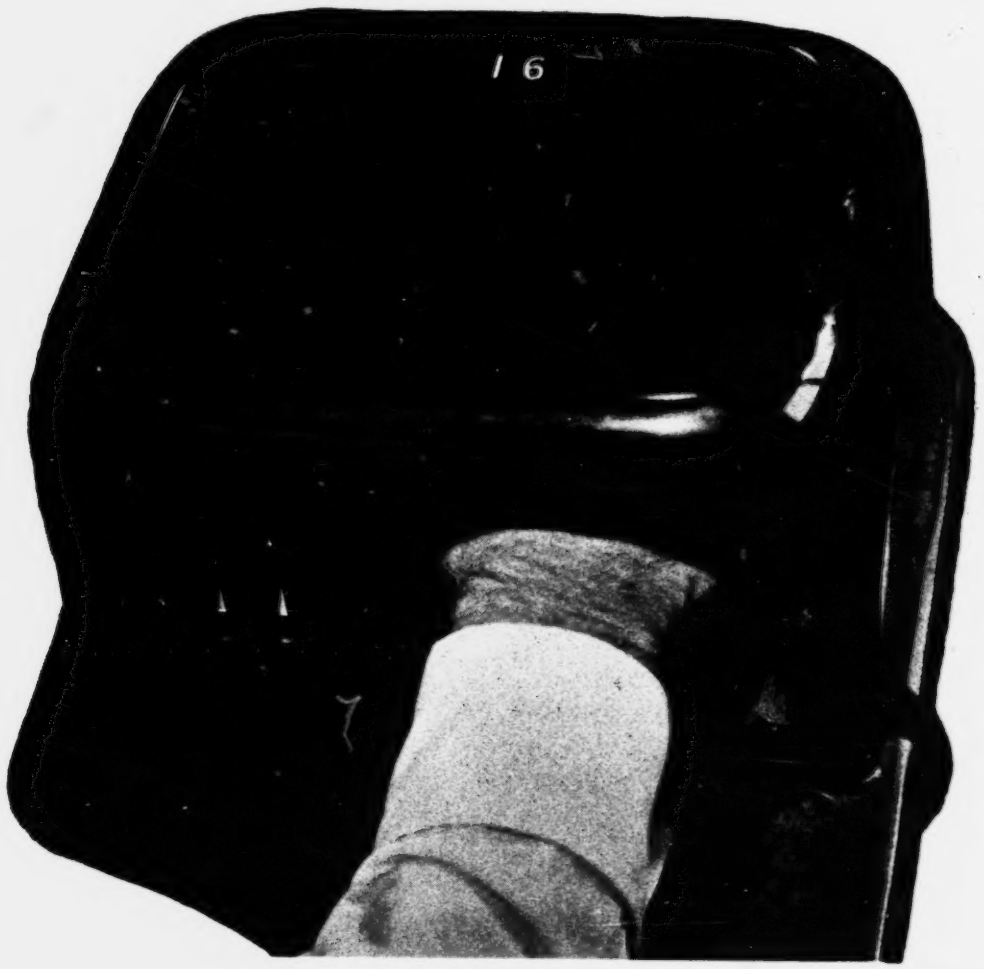

Fig. 3a Response Station with cover in place.

Fig. 3b Response Station with cover removed.

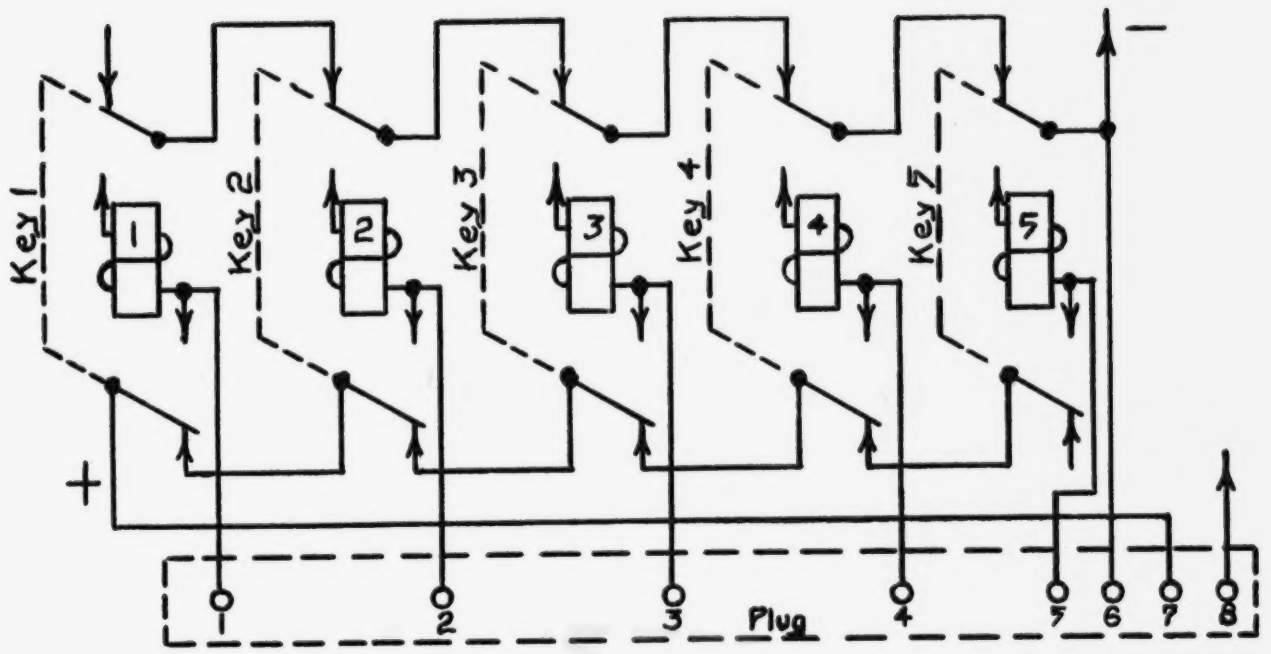

Fig. 4a Partial wiring diagram of individual response station.

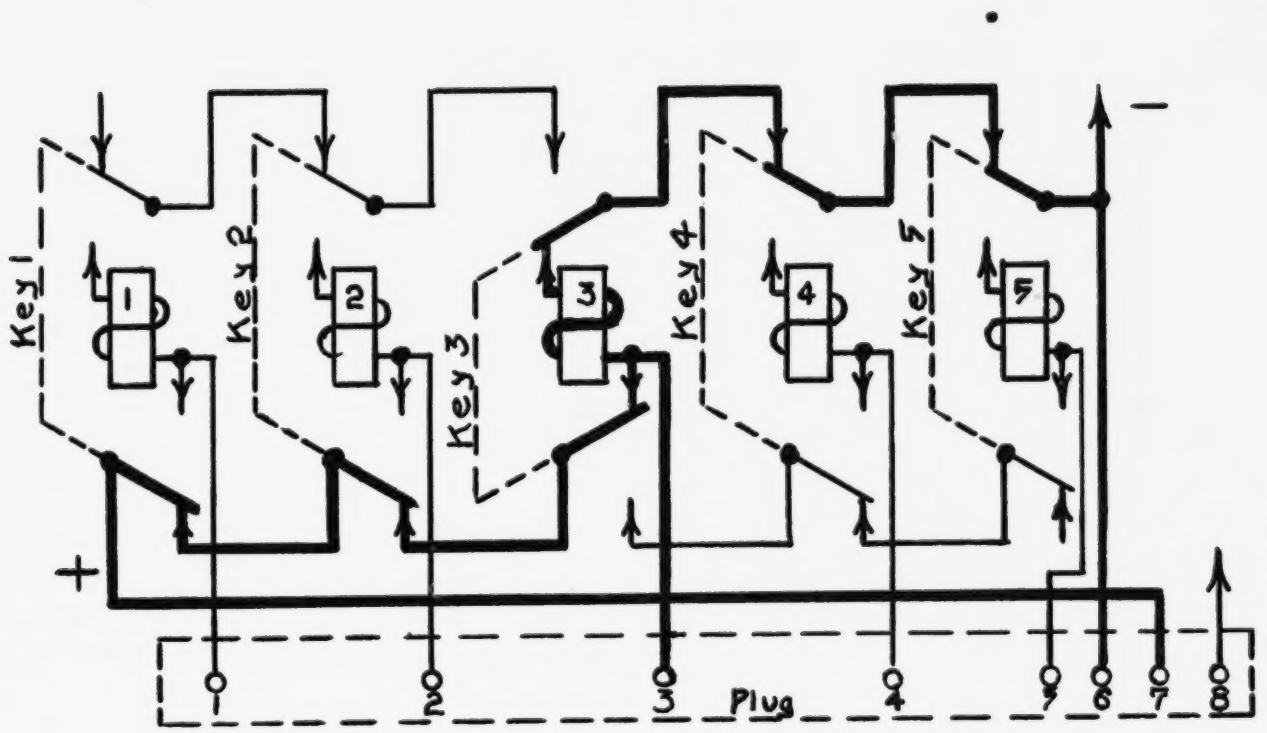

Fig. 4b Partial wiring diagram of individual response station with key number 3 pressed down.

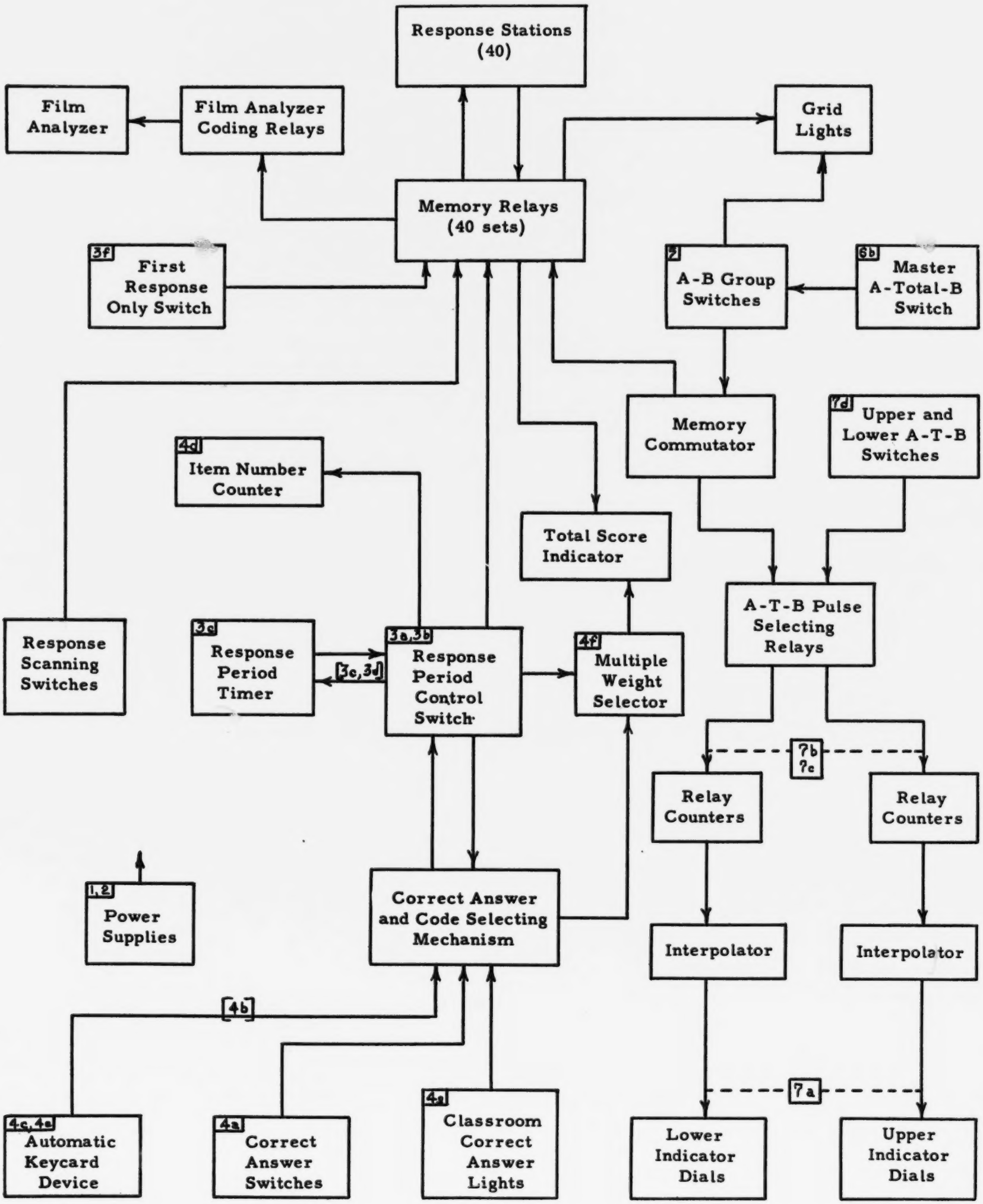

Fig. 5a Block Diagram of the Overall System
Boxed numbers refer to controls in Figs. 5b and 5c.

1. Power switch, one control

2. Panel lights, one control

3. Response period controls, nine controls

    a. Manual response control, one
    b. Remote response control, one
    c. Automatic-manual, one
    d. Timer off-on, one
    e. Timer control; seconds, tens of seconds, minutes, and time after warning signal, four
    f. First response only, one

4. Correct answer controls, eleven controls

    a. Manual correct answer insertion, five
    b. Manual-automatic keycard, one
    c. Keycard press crank, one
    d. Item counter reset, one
    e. Keycard reset, one
    f. Multiple weights, one
    g. Correct answer lights, one

5. A-Vacant-B group switches, forty controls

6. Grid-light controls, seven controls

    a. Response scanning switches, six
    b. Master A-B group switch, one

7. Dial indicator controls, five controls

    a. Dial indicator off-on, one
    b. Counters off-on, one
    c. Recount, one
    d. Dials A-T-B upper and lower, two

Fig. 5b A list of the controls shown in Fig. 5c.

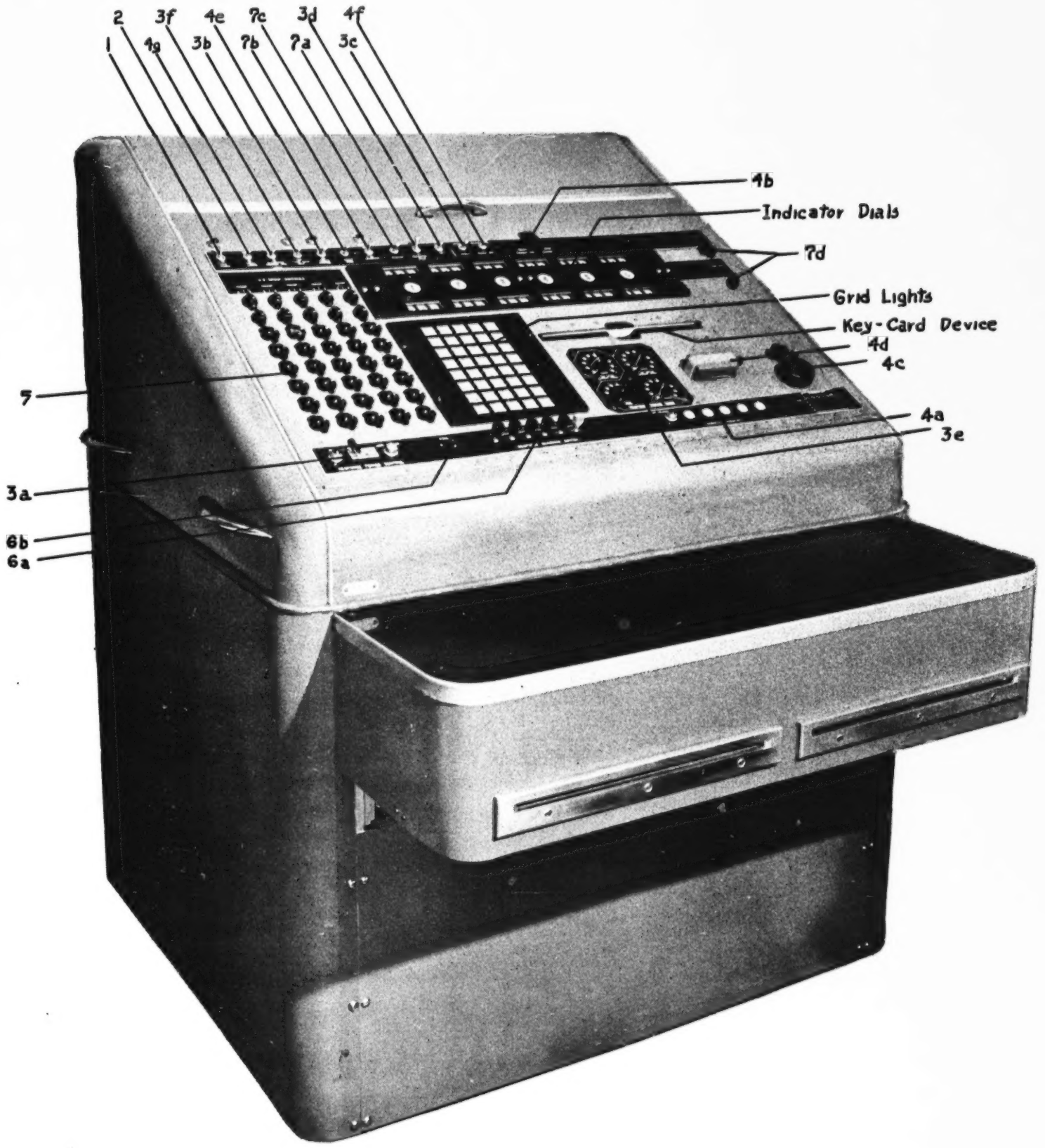

Fig. 5c The Classroom Communicator Console.

B. When stations are unlocked:

1. Subjects may select responses to the next item, and change their choice if they wish.
2. Answers already in response stations are cleared out.
3. The correct answer indication for the previous item is extinguished.
4. Relay counters are cleared out and indicator dials are stopped.
5. Item counter advances.
6. Automatic correct answer selecting mechanism advances.
7. Response period timer starts when this device is used.
8. The memory relays are cleared out.

An interlocking arrangement prevents functions A3 and A5 (above) from occurring before a correct answer has been inserted in the machine.

A few of the above items will be self-explanatory, but each will be explained in detail under the related mechanisms.

Arrangements have been made for controlling the functions of the response period switch remotely (Fig. 5, control 3b). This makes possible the operation of the system from the projector position or from other remote positions in the rear of the room. A sufficient number of automatic devices have been included in the system to make it possible for a complete test to be given with no controls being operated except the response period switch. Still another possibility is that a program of material and questions could be presented by such means as a sound motion picture film, and the response period control operated automatically from the film. This could be made possible by a simple switching device connected to the projector. A testing program, after being initially set up, could then be run with the equipment unattended.

Another function of the various automatic devices is to eliminate instructor error and variability from research results. For example, the key-card selector makes it possible to put into the machine the correct answers to a pre-prepared test for as many as 100 items. The machine then automatically selects the correct answer for each item.

Response Period Timer (Fig. 5, controls 3c, 3d, and 3e).

Closely associated with the response period switch is an electrically operated timer. It has two possible methods of operation:

The first is as a "stop watch". When used for this purpose it is automatically reset and begins to operate when the response period switch is thrown to "response period" position. It stops when the stations are locked, thus informing the operator of the elapsed time.

The second method is automatic control. The timer is set for the desired response-period time interval, and the response period is started in the usual manner. At the end of the preset period, the timer locks the stations. Placing the response period switch in lock-stations position momentarily, and returning it to the response-period position resets the timer and starts the next question period. Operation of the timer is governed by a one r. p. s. synchronous timing motor which operates a set of contacts through a cam to produce 1 second pulses. These pulses are used to drive stepping type switches in units of seconds, tens of seconds, and minutes. The operating range is from one second to ten minutes, in one second intervals. Provisions are also included for operating a warning bell, a preset number of seconds, from 1 to 9, before the termination of the response period.

A unique feature is that the response period timer provides a means for controlling the amount of time allowed for each item of a test. Thus, tests can be time-limited in terms of each of the items which compose it rather than for the test as a whole.

"First Response Only" Switch (Fig. 5, control 3f).

This switch controls a function which, as the name implies, makes it possible to accept only the first reaction or choice of an individual to a question (i. e., the individual cannot alter his original choice). This may be especially important for certain types of attitude studies. Accepting and recording the first response only is accomplished by providing two additional relays with each memory circuit to perform the switching required to lock stations, as decribed on page 11 . Ordinarily these relays are all closed simultaneously when the stations are locked, but for "first response only", each station is locked individually the instant a response is made.

Grid Light System (Eg. 5).

The grid lights consist of a bank of 40 small neon lamps, one for each response station, arranged in the same pattern as the seats in the room. These lamps, with their associated controls, make it possible for the instructor to know at any instant what keys are being pressed at each response station.

The six response scanning switches, labeled 1 through 5 and omit, (Fig. 5, control 6a) serve to energize corresponding common circuits from each of the 40 response stations in the memory relays.

For example, if scanning switch number 1 is pressed, one side of a number 1 relay contact in each relay-memory circuit will be energized. The relay contact will be closed in each memory circuit in which a number 1 response is being registered, thus energizing the corresponding grid lights, which are connected to the other side of these relay contacts.

The response scanning switch circuits also have an inter-connecting circuit with a set of relay contacts in the correct answer circuit such that when a correct answer is inserted by the instructor, it has the same effect as pressing the corresponding response scanning switch, since it causes the grid lights to show to the operator automatically which individuals selected the correct response. The response scanning switches are connected so as to supersede this action. That is, this circuit is instantly broken whenever another response scanning switch is pressed, in order to see which individuals selected the other alternative (incorrect) responses.

The grid light system also includes a set of 40 "A-Vacant-B" switches, (Fig. 5, control 5). These switches are also arranged in the same pattern as the seats in the room. The "A-Vacant-B" switches operate the indicator dials, in a manner to be described below.

When desired, these switches can be set so as to place each individual in either an "A" or "B" group for competitive experiments. If only one group is to be used, the switches are all set to either the "A" or "B" position. Vacant seats are indicated to the machine by placing the corresponding switches in the central or "vacant" position. This "vacant" switch position may also be used when it is desired to have someone "participate" in the test but not to influence or contaminate the results. The "vacant" switch position does not affect the operation of the response stations nor prevent these individuals from accumulating a total score. Thus, a means is provided for selectively composing an effective test group or groups from a given audience without the necessity of informing those eliminated.

A three-position Master A-Total-B switch (Fig. 5, control 6b) is provided so that when "A" and "B" groups are being used, results may be observed on the grid lights for each group separately or for both groups added together.

The grid light system functions at all times, that is, irrespective of the position of the response period switch.

Correct Answer Circuits

In normal operation, the machine is "told" what the correct answer is in order to perform the following functions:

I. Primary Functions:

A. To inform the class immediately what the correct answer or response was when the stations are locked.
B. To distribute points to the total score indicators either according to the correctness of each individual's response, or according to a preset code of multiple weights.

II. Secondary Functions:

A. To light an indicator lamp to remind the instructor which correct answer was inserted, and to draw his attention to those indicator dials which tell him how many of the students selected that answer.
B. To cause the grid lights to indicate who has chosen the correct answer.
C. To light a red warning signal whenever the stations are locked if a correct answer has not been inserted into the console.
D. To delay operation of the total score indicator mechanism when stations are locked until a correct answer is selected.

A two-position switch (Fig. 5, control 4b) permits the correct answer to be inserted into the console in either of two ways: (1) manually, by means of five push buttons (Fig. 5, control 4a), or (2) automatically, by means of a sequence controlled key-card device, to be described later. In either case, the correct answer which is inserted closes one of five relays connected in an interlocking circuit similar to that used for the response station keys (Fig. 3). This makes it possible for the instructor to change the correct answer in case he should accidently press the wrong button.

Multiple Weight Selector (Fig. 5, control 4f).

As mentioned previously, the individual score counters may be operated in either of two ways: (1) For the usual or single weight operation, each individual being tested receives one point on his total score indicator for each question which he answers correctly. (2) For multiple weights, he receives from 0 to 4 points, depending on the code inserted in the machine and the answer he selects. This provides for scoring items for which there is no one correct answer but for which five points on a scale have been assigned different values or weights according to their relative importance. The five alternative responses are spaced equally on a continuum according to some criterion, such as: degree of racial prejudice, clarity of presentation of a section of a film, or speech quality. Five preset code combinations are provided, and one of these is selected for each question by the "correct answer switches", when the system is set for multiple weights. Under these conditions the "correct answer switches" become "multiple weight switches". When the machine is adjusted for this operation, the correct answer lights are not used. Also, the control of the correct answer switches on the operation of the grid lights, mentioned previously, is automatically disconnected. The five "correct answer switches" now control only the selection

of one of five weighted codes, as followes:

Codes	Alternatives					
	1	2	3	4	5	Omit
1	1	2	0	4	3	2
2	0	1	2	3	4	2
3	3	0	1	4	2	2
4	4	3	2	1	0	2
5	2	4	3	0	1	2

Note: These weights may be easily changed at any time by rewiring the multiple weight circuits.

A commutator is used to generate the pulses used in the multiple weight selector. The commutator rotates through one cycle when the response period is ended, provided, of course, that one of the "correct answer switches" has been pressed. There are four output wires, carrying one, two, three, and four pulses, respectively, These wires are connected to the total score indicators through the memory relays. It will be noted from the code chart given above that for code number one, key number one is assigned one point, and for code number two, key number two is assigned one point, and so on. This is the same for both multiple and single weights. It is, therefore, possible simply to disconnect the sections of the commutator which generate the two, three, and four pulses in order, and to switch from multiple weights to single weights.

The Automatic Keycard Device (Fig. 5)

The key-card may be used to insert correct answers or to select weighted codes automatically. Up to 100 items may be inserted into the machine prior to the experiment, thereby relieving the instructor or experimenter of the responsibility of knowing the correct answer or weights for each item during the testing program.

A punched card is inserted in the automatic key card press. On one side of this press are 100 sets of contacts corresponding to the 100 items; while on the other side, running at right angles to these, are five sets of spring-loaded contacts corresponding to the five answers or codes. One hole is punched in the card for each item, thus making possible a contact between the "item" (100 sets of contacts) and "answers" (five sets of spring-loaded contacts). A stepping relay is employed to advance the correct answers from one item to the next. This stepping relay may be set back to the first item at any time by pushing the reset switch (Fig. 5, control 4e).

The Total Score Indicators

These indicators, to which we have referred before, are standard Veeder-Root electrically operated counters (110 volts, a.c.). Forty of these counters have been mounted in a case as shown in Fig. 1. As previously described, they total the score of each individual for either single or multiple weighted test results.

Item Number Counter (Fig. 5)

Another Veeder-Root counter is mounted on the front of the console to indicate the number of the item or question. The counter advances each time the stations are locked.

The Classroom Correct Answer Lights

The correct answer lights are shown in Fig. 1. The panel contains five lights, one behind each number which when lighted is clearly visible from all parts of the room. When the stations are locked, the light corresponding to the correct answer is turned on automatically, thereby informing all subjects simultaneously of the correct choice.

Indicator Dials (Fig. 5)

The number of students selecting each of five possible responses or omit are counted. This information is presented on the dials to the instructor following the presentation of an item and at the end of each response period. There are two sets of indicating dials (upper and lower) which makes it possible to present scores simultaneously for an "A" group and a "B" group. The information is processed in pulse routing and counting circuits.

The memory commutator (which forms the pulses that are counted and presented on the dials) is composed of nine discs. Each disc has rivets located in a circular pattern around its circumference. Connections are made

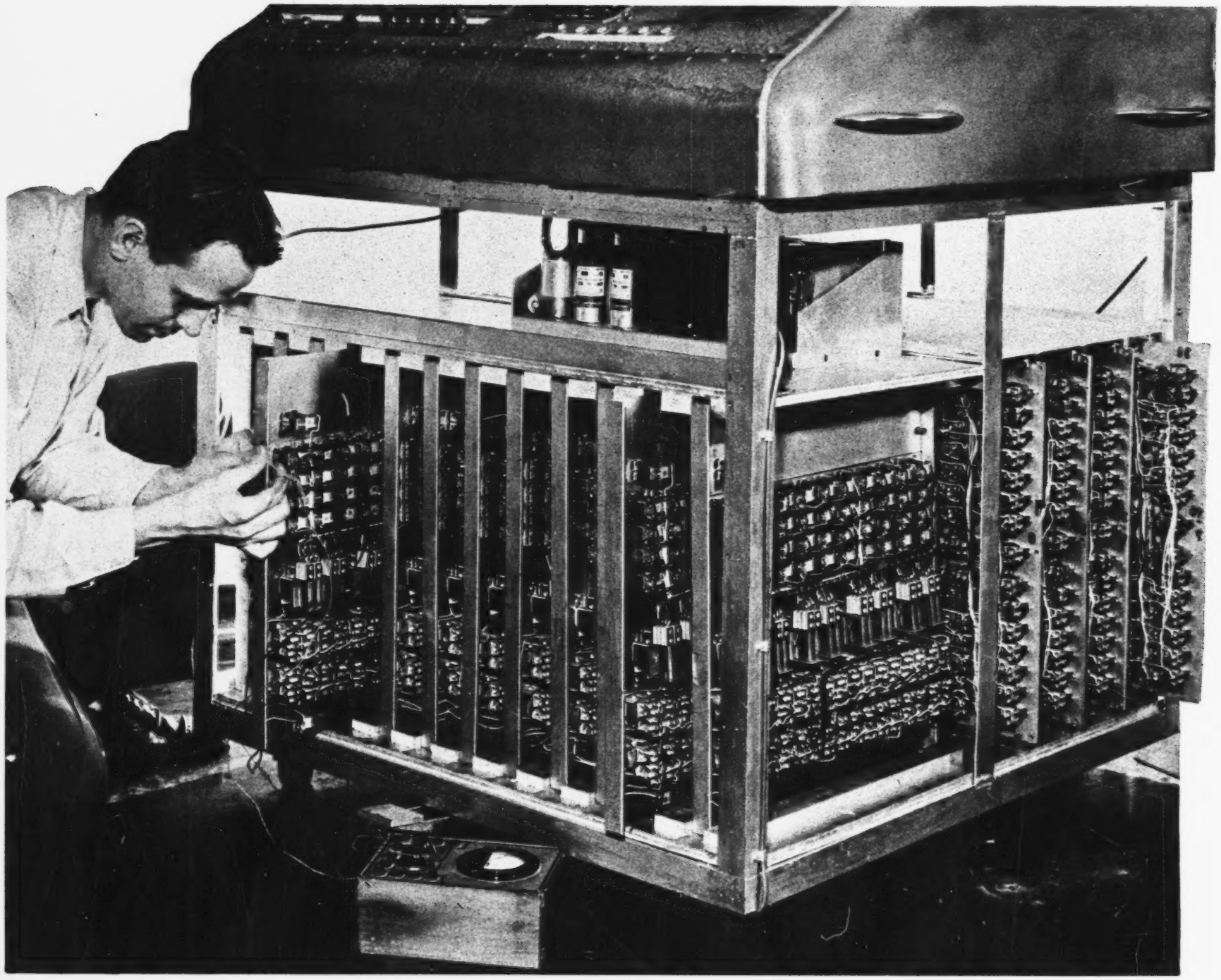

Fig. 6 Classroom Communicator console base with side panels removed showing relay counters (front) and memory relays (rear right).

from all the memory relays associated with the number one keys of the response stations to the number one disc. Similar connections are made from the memory relays representing the other alternatives to their corresponding commutator discs. Another disc is connected to the "A" side of all the "A-Vacant-B" group switches, while still another is connected to the "B" side. The ninth disc is called the sequence control disc and is responsible for starting and stopping the commutator drive motor, setting the counters to zero to begin counting, and to allow the "interpolator" relays to close after the count has been completed.

There are twelve pulse output wires from the memory commutators, one for each alternative (1, 2, 3, 4, 5, and omit) for both the upper and lower dials. These outputs are connected to the twelve counter panels shown in Fig. 6 across the front of the console base.

In operation, the memory commutator motor is indirectly started by locking stations. If we assume that the subject in seat number one pushed key number three, the number three memory relay for the first seat will be closed. When scanning contacts coincide with station one, the scanner on disc number three will be connected to a source of voltage through the memory relays. Now, if we further assume that the subject in seat number one has been placed in the "A" group, then this pulse would be routed through the "A" relay to the counters. Or, if the subject had been placed in the "B" group, the pulse would be routed through the "B" relay. In the case where the "A-Vacant-B" group switch for this seat had been set to the "vacant" position, neither the "A" nor "B" relays would close. Therefore, no connection would be made to the counters. The memory commutator continues to rotate until it has sampled all stations and then is stopped by the sequence control disc. The commutator will be recycled the next time the stations are locked or when the recount switch is closed (Fig. 5, control 7c). If the counter fails to operate properly it will stop counting and turn on a red light on the console panel. This unique feature precludes incorrect reading from this source.

The counter relays count the pulses from the memory commutator and close one of 41 "interpolator" relays corresponding to the count made. The interpolator relays, in turn, determine the number presented on the dial indicators. The dial indicators use a unique method of presenting numbers. Strobotron flash tubes are used to illuminate opaque numerals printed around the circumference of a translucent rotating cylinder. These tubes are discharged every time the desired numeral comes around. There are two cylinders, one for the upper dials and one for the lower dials, and each cylinder is capable of indicating six three-digit numbers. This requires a total of 36 flash tubes. The desired numerals are illuminated at the proper time by employing the combination of a ten point commutator (attached to the ends of the cylinders) and the interpolator relays. The relays may be wired to indicate any one, two, or three digit number. It is, therefore, potentially possible to indicate percentages instead of numbers if the relays were rewired. However, the relays would have to be wired every time the number of students in the class changed.

An attempt was made to incorporate a device which would in effect rewire the relays by inserting a card (with conductors fastened to it) into a network press. A model was constructed which contained 14,400 contacts. (Forty relays times 3 digit contacts each, times six alternatives, times two groups, times ten numerals, zero through nine.) The model was a good "demonstration of principle" in that it showed that the idea was sound. However, it did not work reliably enough to be used in a research program. Accordingly, it was decided that for the time being the relays should be wired directly for presenting only the numbers of individuals giving each alternative response, rather than rebuilding the network press. Further research and development work and precision shopwork are needed to perfect this device, in order to present the percentage of individuals giving each alternative response.

The information presented on the upper and lower dials is controlled by the two three-position switches shown in Fig. 5 (controls 7d). Thus, either of the dials may be used to indicate the number of students in the "A", "B", or total group who select each alternative to a multiple choice question.

The Film Analyzer (Fig. 1)

The Film Analyzer is a continuous-recording polygraph, which records the individual responses and prints them on a chart with time markers. This recorder is completely described in a separate report.[1] The Film Analyzer coding relays shown in Fig. 2 are housed in the console of the Classroom Communicator.

The Power Supplies

There are two power supplies which have 24 volt DC outputs for operating the relay systems. One is used continuously and the other is employed only while the stations are locked. The second supply was used because of the increased load during the lock station period. A 500 volt supply is used to operate the strobotron flash tubes of the dial indicators. The 8000 volt trigger required to ionize the strobotrons is supplied by two automotive ignition coils.

OPERATIONAL CHARACTERISTICS

Although the experimental equipment described above has only recently been completed, the limited use to which it has been put thus far has suggested several modifications and additions. One such addition would be another form of correct answer weighting. This would provide for assigning from one to four points for the correct answer where the test items vary in their degree of importance. Another improvement which needs to be made is to reduce the noise made by the indicator dials. This could be done by replacing the breaker point assembly which triggers the strobotrons by an electronic

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[1] Technical Report SDC 269-7-15. The Film Analyzer.

switch. A third modification involves the response stations which are very critically adjusted. They could be redesigned to improve their reliability by reducing the mass of the key assembly attached to the lock down relays.

No one of the components fails very often, but there are probably ten thousand possible points of equipment failure. Any complex device such as the Classroom Communicator must have a large safety factor built into its individual components. It would not be realistic to expect the first experimental model of any device as complex as the Classroom Communicator to give perfect performance.

Before this equipment is used as a research tool, it will be put through a series of tests designed to evaluate its characteristics. This program will test the performance characteristics of the equipment, indicate additional modifications and improvements, and evaluate their relative importance. Any thorough discussion of the operational characteristics of this instrument must necessarily wait until the test program has been completed at which time a supplementary report will be issued.

The evaluation program now in progress will test the many functions of the equipment. The demands on the experimenter and subjects as well as the performance of the device will be measured. Some examples of the characteristics of the system which are being evaluated are as follows:

1. Outline the situations in which the Classroom Communicator might be employed.

2. Determine the demands made by the equipment both on the instructor and students.

3. In terms of these demands, conduct experiments to determine the limits of reliability of the interaction of instructor and students with the Classroom Communicator.

4. Discriminate between the use of the machine with naive subjects who will be oriented briefly, as compared with trained subjects. Outline a training session for the inexperienced subjects.

Immediately following the initial testing of the equipment, psychological experimentation will be commenced. Experiments have already been outlined to

investigate the following problems:

1. Study the effects on learning of "immediate knowledge of results".

2. Study various methods of "reinforcing" correct responses and and "extinguishing" incorrect responses.

3. Explore the potentialities of the Classroom Communicator for motivating subjects by promoting involvement of subjects in the instructional program.

4. Testing the possibilities of social facilitation of learning through group cooperation and competition.

Functional Characteristics of the Experimental Model

It would seem to be desirable at this point to discuss again the functional characteristics of the Classroom Communicator. The specifications which were stated and agreed to by the Planning Committee were given on pp. 4 to 7 . These ideal requirements were expected to differ in some respects from the functional characteristics which would actually be realized by the equipment when it was completed.

The following is a list of the actual performance characteristics of the system:

1. The system gives immediate indication to an observer, instructor or investigator of the distribution of correct and incorrect responses made by individuals of a group being tested.

2. The system registers, summates and presents the total test score for each individual of the group at the end of the test period.

3. The device provides for the insertion of correct answers for each test item either by the operator or by a pre-punched correct answer card for as many as 100 items of a test.

4. The system provides a semi-private response station for each individual of a group of as many as forty people: each response station has five keys which provide for a maximum of five alternative responses.

5. The device presents automatically and immediately after each response period is terminated the correct answer to a question, and this indication is clearly observable by the group through numbered correct answer lights. If the instructor wishes, he may turn off the correct answer light. The correct answer is shown to the instructor by a lighted number on the console panel. If the automatic key-card device is used, the card is in itself a permanent record of the correct answers. Or, if the correct answers are inserted manually, a permanent record may be made by using the Film Analyzer polygraph.

6. The response stations prevent the possibilities of multiple answers to an item,for only one response from each station can be recorded at a time. However, individuals can change their responses or choices within the limits of a predetermined response period. The duration of this response period can be varied and timed precisely from 1 second to 10 minutes. A warning bell may be used to indicate to the subjects being tested the approaching end of the response period. The instructor can determine the beginning and end of the response period by operating a switch by hand.

7. The system achieves and exceeds the specified accuracy in registering, indicating and recording results. This is accomplished by the use of a discrete number system.

8. All dials on the console panel have been designed and illuminated, so that the system can be operated in a dark room. This illumination does not interfere with the projected qualities of a motion picture.

9. The system provides for the omission of response to any item by the subjects. The instructor may be informed immediately of the specific individuals who omitted responses and their total number.

10. The system has a grid of lights operated by switches which permit the instructor to check on the kind of response made by each individual.

11. The dial indicators provide the instructor or investigator with the number of responses to each alternative including omit.

12. There is provision for arranging the total group into three subgroups, A-group, B-group, and those to be eliminated from scoring. The responses for both A-and B-groups can be handled as described above for the total group. Individuals may or may not be told the group into which they have been put. Those individuals who have been eliminated from the scoring system may operate the response stations along with the others in the group but their responses will not be counted. They may or may not be informed of this fact.

13. By using the Film Analyzer in connection with the Classroom Communicator a complete record in symbols can be printed of every response made by each individual. Furthermore, a record can be made of all response times. Thus, the system can be used for a variety of immediate or delayed response timing measurements.

14. The system will add scores on multiple choice items with the items differentially weighted. Furthermore, the items on a scale can be presented in five different orders, and omits are assigned two points in each case as shown in the chart on page 21.

15. Throughout the design of the system, an attempt was made to facilitate servicing and repairing.

Note: The system has been built, as much as was practical, of standard parts and assemblies.

This summary list of functional characteristics shows the high degree to which the equipment meets the essential specifications which were originally laid down. However, there were some requirements which have not as yet been fully satisfied. The most important of these are the following:

1. The bulk and complexity of the present experimental model indicated that it is impractical to enlarge the system to accommodate additional response stations. In order to have a system that will handle large numbers of response stations for large audiences an electronic design would be preferable.

2. It is inherently possible to calculate percentage scores with the present system with the necessary accuracy and reliability. The soundness of the circuit design used in the Classroom Communicator for accomplishing this has been demonstrated. The network presses, however, must be rebuilt with greater precision than it was possible to achieve with the shop facilities available at this Institution.

3. The system which has been developed is movable, but it is not easily portable. However, some elements of the system could be incorporated into a system which would be satisfactory for certain purposes, and this simplified model could be made easily portable for field testing.

4. With the present experimental model it is not so convenient as might be desirable for an operator to check the full performance of each response station and connected circuits, i.e., to check whether or not they are functioning properly by merely pushing a button or observing a light.

There are a few other "mildly desirable" but not "essential" requirements which are not met by the present model.

USES OF THE CLASSROOM COMMUNICATOR

The Classroom Communicator has been planned, designed and built for use as a research instrument, and especially for research on instructional and informational types of communication programs. Therefore, it will be found most useful for this kind of work.

Another of its most important uses will be that the present experimental model, when tested, can serve as a starting point for other models. Parts of the present rather complex system may be used as patterns for simpler systems which may be needed to serve more limited functions than are served by the experimental model.

On the basis of work that has been done and the testing or proving program which is now under way, models incorporating the essential elements of the Classroom Communicator can be developed, mass produced, and distributed for use in educational institutions, and in training and testing centers. It is conceivable that the system may find very important uses in test construction and testing programs. This would be especially true if the system were linked with the punch card system of calculators.

The designs embodied in the Film Analyzer and the Classroom Communicator may prove very useful for future equipment to serve legislative bodies like the United States Congress or international congresses like the General Assembly of the United Nations where votes are taken and the results need to be summarized and made known immediately. Furthermore, the systems could be used in order to get complete records of the responses of individuals participating in policy making or decision groups.

It is highly probable as operational testing proceeds and as people with special needs become aware of the potentialities of the Classroom Communicator that other uses will become evident for which the equipment can be adapted.